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Platelet-Rich Plasma vs. Traditional Surgical and Nonsurgical Interventions for Rotator Cuff Tendinopathies

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Platelet-Rich Plasma vs. Traditional Surgical and Nonsurgical Interventions for Rotator Cuff Tendinopathies

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Abstract:

Background:

Rotator cuff tendinopathies present as one of the most common musculoskeletal injuries of the upper extremity. The rotator cuff consists of four muscles: the supraspinatus, infraspinatus, teres minor, and subscapularis with the supraspinatus the most injured of the group. Over time, variations regarding treatment through surgical or nonsurgical interventions have remained constant. In recent years, the use of platelet-rich plasma (PRP) as an additional alternative has become popular to promote healing and improve functionality of the shoulder. The purpose of this clinical review using various study designs is to assess if the platelet-rich plasma injections are more effective when used with traditional surgical or nonsurgical interventions for the long-term outcomes of adult patients with rotator cuff tendinopathies.

Methods:

A systematic database search was conducted for peer-reviewed articles and studies dated from 2018 to present using Google Scholar, PubMed, and ScienceDirect. Information pertinent to this clinical review consisted of 20 articles allowing for an all-encompassing comparative foundation to determine the most effective long-term treatment for rotator cuff tendinopathies. *CURRENT Medical Diagnosis & Treatment* was also used.

Conclusion:

After evaluating all of the data collected to determine if platelet-rich plasma is effective in improving pain, range of motion, and functionality for patients with rotator cuff tendinopathies, results widely varied. At this time, it seems as if more research needs to be conducted because although it has been proven to show improvements, there are still variable results for both pre and post-operative intervention use of PRP..

Introduction:

The shoulder is the most mobile large joint in the human body and because of this, it is going to be prone for injury, which is commonly associated with the rotator cuff muscles. The rotator cuff is composed of 4 major muscles: the supraspinatus, infraspinatus, teres minor, and subscapularis.[1] These muscles together promote stability of the shoulder while also allowing for major movements of the upper extremity. The supraspinatus originates at the supraspinous fossa of the scapula and inserts onto the greater tuberosity of the humerus. Both the infraspinatus and teres minor originate at the infraspinous process of the scapula and insert at the greater tuberosity of the humerus. The subscapularis originates at the subscapular fossa and inserts at the lesser tuberosity of the humerus.[1] Due to the structure in which these muscles exist in the shoulder, the supraspinatus tends to be the most likely to experience tendinopathies.

There are many causes in which one may experience rotator cuff tendinopathies: structural abnormalities such as a downward sloping acromion causing an impingement of the suprascapular nerve, age related degenerative processes that weaken the muscle and tendon, or biomechanical factors such as tensile overload in external rotation, abduction, and extension of the humerus.[2] It is quite common to see such injuries in sports heavily involved in the use of overhead movements such as baseball, tennis, and football with the most significant being a full thickness rotator cuff tear. When a full thickness rotator cuff tear takes place typically occurring in the supraspinatus, the patient will lose structural integrity of the shoulder. If structural integrity is compromised, a superior subluxation of the humeral head will force the intact portion of the supraspinatus to move anteriorly with infraspinatus moving posteriorly.[2] This will cause pain and loss of functionality of the shoulder for the patient with standard overhead movements due to not only the tear but now the presence of a possible impingement. A systematic review

and meta-analysis published in the Journal of Rehabilitation Medicine by Leong *et al* to determine the major risk factors for rotator cuff tendinopathies. The data was retrieved from 16 different studies with patients presenting with various conditions such as rotator cuff tendinopathies, shoulder impingements, and subacromial bursitis. What they found was that an age > 50 years, diabetes, and overhead activities were the most common risk factors associated with developing rotator cuff tendinopathies and shoulder injuries.[3] For management of pain and to improve functionality of the shoulder, there are both surgical and nonsurgical options for the patient.

Traditional nonsurgical and surgical interventions have remained the standard of care for years regarding the treatment of rotator cuff tendinopathies. Many surgeons advocate for nonsurgical methods prior to surgery to determine if there is a possibility for pain reduction and improvement of functionality while being as minimally invasive as possible. Options for traditional nonsurgical interventions consist of physical therapy, non-steroidal anti-inflammatory medications, corticosteroid injections, and nerve blocks/ablations.[4] If these interventions fail, surgical interventions are typically the next step in treatment.

Platelet-rich plasma (PRP) injections have become a regularly used alternative to traditional surgical and nonsurgical interventions in rotator cuff tendinopathies. It is injected into the injured shoulder, typically guided by ultrasound, to promote healing of the damaged rotator cuff. The platelet-rich plasma is used because the high concentrations of platelets promote the release of growth factors in the tissue leading to regeneration and improved healing while being much less invasive than surgical interventions.[5]

Rotator cuff tendinopathies have become increasingly more common and treatment methods continue to evolve. The aim of this clinical review is to assess if platelet-rich plasma

injections prove to be more beneficial in long-term outcomes compared to traditional surgical and nonsurgical interventions for pain, range of motion, and functionality in adult populations. Each study design has specific measurements to assess these factors utilizing physical characteristics, self-evaluation surveys, and imaging. As monotherapy, it is hypothesized that PRP will show to be better in the short-term for pain, range of motion, and functionality with surgery being more beneficial in the long-term. As combo therapy, it is also hypothesized that the use of PRP and surgery together will be the most effective for overall long-term health due to the immediate interventions of surgery and healing factors of the platelet-rich plasma to decrease pain, and improve range of motion and functionality.

Background:

Surgical intervention:

Of the common modalities for rotator cuff tendinopathies, surgical interventions remain popular for medium thickness to full thickness tears or acromion structural abnormalities. Surgery is typically used due to the persistent symptoms and functional impairment limiting a patient after nonsurgical interventions have failed.

These surgical interventions for rotator cuff tendinopathies allow for patients the opportunity to accelerate the healing process and improve limitations. Though some surgeons are interested in providing nonsurgical interventions to alleviate and improve symptoms prior to performing surgery, others believe that surgery is the intervention of choice because of the immediate repair. Surgery is most performed arthroscopically where surgeons use the double-row technique to properly anchor the rotator cuff tear to the humerus while also executing and debridement necessary to promote healing and functionality.[14] Diagram of the procedure can be found in the appendix under image 1.[6]

A review of surgical techniques, animal models, and new technologies currently under development was published in the Journal of Shoulder and Elbow Surgery by Deprés-Tremblay *et al*. Various arthroscopic and open surgical techniques exist for the repair of rotator cuff tendinopathies: transosseous equivalent repair (TOE), single row suture anchor, or double row suture anchor.[6] The double row shows the greatest rate of improvement in tendon healing, but all interventions discussed have been shown to be effective. In a comprehensive review of arthroscopic double row rotator cuff repairs from Aydin *et al.*, the double row technique is described as two rows of anchors, one medial and one lateral, passed through the torn rotator cuff and into greater tuberosity of the humerus securing the damaged tissue back in its anatomically correct position.[7] By doing so, without too much tension applied, the tendon can regenerate, and biomechanical function can be restored because structural integrity of the shoulder is restored.

Surgical interventions do not come without financial implications. It has previously been stated that the average cost of a rotator cuff repair is between $6374 and $13,270, thought to be more cost effective than nonsurgical management saving the United States $3.44 billion annually.[8] In the Journal of Shoulder and Elbow Surgery, an analysis of 40,618 rotator cuff repairs was conducted by Li *et al* to assess the primary cost drivers of the procedure.[8] With the reported number of rotator cuff repairs at 250,000+ in the United States annually, understanding the dynamics of cost is essential in selecting a course of interventions. This study using the State and Ambulatory Surgery and Services Databases (SASD) analyzed patient and surgical contributions from 6 states to the overall cost of rotator cuff surgery. By considering factors such as demographics, income, comorbidities, and insurance provider along with the surgical factors such as anchors, anesthesia, and subacromial decompression, a true representation of cost can be demonstrated. Of the cases analyzed, it was determined that the average cost was $25,353 but

had a significant standard deviation of $16,747 depending on state. With subacromial decompression adding $4992 and the cost of each anchor being $1249, there are major cost drivers that need to be considered when performing surgery.[8]

When truly assessing the success of a treatment modality, long-term outcomes regarding functionality and reduction in limitations should be greatly considered. In Revista Brasileira de Ortopedia, Miyazaki *et al* conducted a study by evaluating patients who received arthroscopic rotator cuff surgery for massive rotator cuff tears and evaluated their improvements or limitations in functionality. Originally in 2006, there were 61 patients who participated in the study and 89% of them reported good to excellent results according to the UCLA criteria for functionality.[9] But the results they were looking for were more specific to long-term outcomes, so they also went on to follow-up a minimum of 8-years later beginning in 2014 at the earliest. In that subsequent evaluation, only 35 patients were eligible for follow-up with 15 not being able to be located, one refusing to participate, and two lost to death. Observing lateral and medial range of motion as well as elevation, 91% of patients reported good to excellent results. Re-injury was reported in 3 of the 35 cases.[9] It remains important to note that though there was a significant loss in participation for follow-up, the remaining group showed very positive outcomes regarding functionality and range of motion post-arthroscopy for the rotator cuff repair.

In a similar study, The American Journal of Sports Medicine also published a study by Randelli *et al* to determine the long-term results of arthroscopic rotator cuff surgery 10-years post-operation. In total, 169 patients were enrolled in the study where 149 completed the telephone portion and only a total of 102 were able to fulfill the final evaluation.[10] The true goal was to assess if the patient's 10-years post-operation intact supraspinatus tendon, integrity of the tendon, and functional and radiological outcomes. When the patient reached the 10-year mark,

they received a phone call to see if they had undergone reoperation to collect Simple Assessment Numeric Evaluation, Numeric Rating Scale, American Shoulder and Elbow Surgeons, and Simple Shoulder Test scores.

After these scores were collected, they were invited for a follow-up visit to complete the Constant-Murley Score (CMS) to assess strength in forward flexion and abduction. Then followed the radiograph and ultrasound assessments to visualize the structural integrity of the shoulder. When analyzing the data, one critical concern that was noted included the size of the initial tear. Those who had larger initial tears had 2.18-higher risk to present with a non intact rotator cuff.[10] These patients also showed a slight difference in CMS but nothing significant to note. One other remarkable finding was only about 50% of these patients evaluated still had an intact rotator cuff.[10] Those who did still have their rotator cuff still intact reported higher functional outcomes, satisfaction, and reduced progression of osteoarthritis shown on radiograph. Refer to table 1 of study for statistical analysis.[10] It is difficult to directly correlate the original significance of the rotator cuff tear to the long-term outcome because there was no follow-up in-between, not enough predictive factors assessed, and these patients were not observed prior to their operation all in which could have contributed to failure of the rotator cuff repair. But when analyzing the initial size of the tear, results of this study show a significant correlation to outcomes.

Traditional nonsurgical interventions:

Typically, before navigating options of surgical interventions for rotator cuff tendinopathies, nonsurgical options are fully utilized. It has been shown that these are viable options to identify if improvements can be made to increase functionality of the upper extremity and decrease discomfort associated with the injury. The standard of care for traditional

nonsurgical interventions centers around options such as physical therapy, non-steroidal anti-inflammatory medications, corticosteroid injections, and nerve blocks/ablations.[4] With rotator cuff tendinopathies being the most common cause of pain and loss of function in the shoulder, nonsurgical interventions are important in a first-line attempt at rehabilitating the injury. Since the duty of the rotator cuff is not only to provide shoulder movement and function but also stability, it is important to strengthen and regain that stability to properly promote healing so the patient can regain function.

Physical therapy is targeted to regain function while improving strength of muscles around the rotator cuff and improving flexibility. By doing so, improvements of biomechanical function can be made to improve healing and decrease likelihood for reinjury.[4] Non-steroidal anti-inflammatory medications are a mainstay for pain management.[4] Corticosteroid injections work efficiently in reducing inflammation and pain allowing for improved functionality.[4] It is common for patients to receive these as polytherapy increasing their overall likelihood for greater long-term outcomes. The nerve blocks/ablations are reserved for patients who have not shown improvement with other nonsurgical interventions and are also not a candidate for surgery.[4]

In most cases, surgeons will opt for nonsurgical management of these injuries first if the injury is not severely symptomatic after an acute injury. It is important to understand the injury itself before prescribing treatment such as thickness of the tear, acute or long-standing injury, age of the patient, previous operation, etc. Aboelmagd *et al* evaluated traditional nonsurgical options for treatment in eligible patients with rotator cuff injuries. Physiotherapy was the first in which they assessed. The complete picture of the patient and injury is important in the management and treatment of tendinopathies. Factors such as strengthening muscles around the joint, improving

posture, and improving biomechanical axis allowing for improved function will determine level of importance for each patient. In two studies included in this paper, using physiotherapy as initial management showed a success rate ranging from 75-91% in patients who suffered a rotator cuff tear regarding functionality and strengthening of the joint.[4] Non-steroidal anti-inflammatory medications were also used in such patients. Though deemed successful in the short term for pain relief, the NSAIDs were not studied extensively in the long term, mainly because other interventions were needed and they do not specifically promote healing as the alternatives would.

In addition to physiotherapy and NSAIDs, corticosteroid injections have remained a mainstay in rotator cuff tendinopathy management for years. Used for both diagnostic and therapeutic treatment, they are used to reduce inflammation allowing patients to continue their physiotherapy program. But very similarly to the NSAIDs, the corticosteroids show a reduction in short term pain and increased functionality at 6 weeks but limit long term effect. Penning *et al* concluded that at 26 weeks, 21% of patients that received a placebo injection showed a reduction in pain compared to the 20% who received corticosteroid injections.[11] Pain scores were assessed using the visual analogue score (VAS) to give a standard associated with the patient's baseline. The scale is used as a measurement tool to help measure characteristics that may not be directly measurable, such as pain. Ultimately, the injections become serial so cost then becomes something to take into account.

When patients suffer from end stage rotator cuff tendinopathies, are not eligible for surgical interventions, and have exhausted all other options, nerve blocks/ablations can be used. This treatment method is used mainly as pain management since there is no promotion of healing in the area. The suprascapular nerve is the targeted nerve as it supplies sensation to the shoulder

capsule.[4] Kane *et al* demonstrated that the ablation of the nerve reduced pain up to 6 months according to VAS, Constant score, and Oxford score.

When implementing traditional nonsurgical interventions to treat rotator cuff tendinopathies, it is vital to assess pain and functionality to determine success of the treatment for patients. In an article by Bush *et al* published in the World Journal of Orthopedics, a cohort of 59 patients with full-thickness rotator cuff tears confirmed by MRI or ultrasound were treated with nonsurgical interventions such as physical therapy and NSAIDs and had a follow-up at 6 months and then a year and annually after that to identify the clinical significance of their progress.[12] These patients were required to provide basic patient demographics, comorbidities, smoking status, and previous injury status all while partaking in the prescribed physical therapy program. Their program consisted of stretching, resistance band strengthening, and scapular stabilization exercises. They were assessed at baseline and each subsequent follow-up using the Western Ontario Rotator Cuff (WORC) index, American Shoulder, and Elbow Surgeons score, Visual Analog Scale, and Single Assessment Numerical Evaluation with the WORC score being the primary assessment tool.[12] Specifically, the WORC score is developed based on a questionnaire the patient fills out to determine their pain and limitations associated with their rotator cuff tendinopathy.

In the case of this study, with the use of nonsurgical interventions, all patients reported improvement from their baseline evaluation with no significant changes from one to two years.[12] Regressions in scores were associated with the female gender, smoking, and advanced subscapularis fatty infiltrations. The baseline WORC score was 46.05 with a standard deviation of 21.61. At the final follow-up (either one or two years after baseline was established) the score was 63.58 with a standard deviation of 25.6 showing an improvement of 17.53 from baseline.[12]

With pain being quite subjective, the general improvement regarding pain and functionality in this study in all participants is important in validating how nonsurgical interventions can improve patient outcomes in the short to intermediate timeline.

Platelet-rich Plasma Injections:

As the treatment for rotator cuff tendinopathies has evolved, alternatives to surgery and the traditional nonsurgical modalities have developed. Platelet-rich plasma (PRP) has become one of the most popular and most researched in recent years. It is a biologic solution containing high platelet concentrations which release growth factors to promote healing in torn tendons of the rotator cuff. By injecting into the injured shoulder, the healing process is enhanced allowing for more rapid regeneration of the tissue. The injection is typically aided by ultrasound to increase accuracy.

Published in The Egyptian Rheumatologist, Ibrahim *et al* conducted a study comparing PRP to corticosteroid injections for rotator cuff tendinopathies and their effects on shoulder pain, disability, range of motion (ROM), and healing observed by ultrasound.[6] The patient population consisted of 30 people from 23-66 years with rotator cuff tendinopathies of varying degrees assigned to two groups split evenly: 15 assigned to PRP treatment and 15 assigned to corticosteroid treatment. Pain was evaluated using the Visual Analogue Scale (VAS), ROM was measured using goniometer, functionality/disability was measured using the Shoulder Disability Questionnaire (SDQ), and specific rotator cuff tests such as the empty-can for supraspinatus, external rotation lag for infraspinatus, lift-off of subscapularis, and horn-blower sign for teres minor were also used. Patients were assessed at time of injection and then participated in a 7-week exercise program and then assessed again at the 2-month mark. According to the findings, both PRP and corticosteroid injections showed great improvement for improvement of pain,

ROM and disability/functionality of the shoulder.[5] There were no significant differences in the measurable findings. Regarding the ultrasound findings, PRP promoted slightly better healing and also presented a lesser likelihood in developing tendinitis and bursitis compared to corticosteroids.[5]

Similarly to the above study, the Journal of Orthopaedic Surgery and Research by Dadgostar *et al* published a study comparing corticosteroids to PRP in the treatment and management of rotator cuff tendinopathies. A total of 58 patients were in the study evaluating pain with VAS as the primary assessment point with range of motion, WORC score, DASH score, and supraspinatus thickness also analyzed. Not discussed in previous studies, the DASH score is a 30-question questionnaire used to self-report physical function and symptoms a patient may be experiencing specific to the upper extremity. Patients were evaluated at baseline, one week, one month, and 3 months. The difference between this study compared to the previous study is that Dadgostar *et al* came to the conclusion that the PRP group showed significant improvement in VAS and ROM at 3 months compared to the corticosteroid group.[13] Other statistical outputs remained similar and were not statistically relevant denoting any differences. The baseline and 3-month VAS and ROM scores have been attached as table 2 and 3 in the appendix.[13] Though many results provided similar statistical improvements, the improvements in VAS and ROM express that PRP may be a viable option in pre-surgical management of rotator cuff tendinopathies in substitute for corticosteroids.

An alternative study published in the Journal of Orthopaedic Surgery and Research by Kim *et al* studied the differences in outcomes of individuals with rotator cuff tendinopathies using PRP and general physical therapy modalities.[14] The main objective of this study was to determine the importance of the cellular component of PRP compared to the importance of

regaining function and strength using physical therapy. Patients were required to be 18 years of age, needed a rotator cuff tendinopathy confirmed by ultrasound, no prior rotator cuff surgery or on any medications such as NSAIDs or steroid injections, and no presence of infection. A total of 30 patients were divided into two groups: the PRP group who received a 2ml injection and the exercise group who took part in strengthening programs for the rotator cuff. The majority of the exercise program consisted of scapular stabilization as well as infraspinatus and subscapularis strengthening using isometric and isotonic exercise with dumbbells and Thera-bands. Patients were asked to perform their exercises for 20 minutes 4 times per week. Follow-up assessments were performed at 6, 12, and 24 weeks using the American Shoulder and Elbow Surgeons (ASES), Constant-Murley score, and numeric rating scale (NRS) all to assess pain and functionality while also using ultrasound to determine thickness and integrity of the rotator cuff. For the PRP group, growth factors were also measured due to the promotion PRP has on growth factors and healing.

Regarding outcomes, of the 30 patients recruited, 8 of the 15 in the PRP group and 7 of the 15 in the exercise group did not complete their full 24-month follow-up. One of the significant findings was the 24-week ASES score after linear regression as it was much improved for the PRP group compared to the exercise group.[14] For the PRP group, there was a change from 42.8 with a standard deviation of 18.4 to 68.0 with a standard deviation of 23.8. The control group started at a baseline of 59.0 with a standard deviation of 13.4 and improved to 79.7 with a standard deviation of 14.1.[14] The exercise group also expressed thicker supraspinatus on ultrasound.[14] When measuring growth factors, the PRP group showed a higher amount present allowing for a greater environment to promote healing. Limitations with this study are a small sample size due to dropout rates and also the duration only being 24 weeks.

Continuing with the comparisons to PRP, Lin *et al* conducted a meta-analysis study comparing PRP to sham injections, no injections, or physiotherapy in MDPI.[15] Very similar to the previous study by Kim *et al*, patients were assessed at 3-6, 12, and 24 weeks to determine the effectiveness of treatment on pain reduction (primary outcome) and functional improvement (secondary outcome). They also went about incorporating patients strictly with similar rotator cuff tendinopathies such as tendinosis, partial tears, and impingements and excluded full-thickness tears, trauma, calcific rotator cuff disease, and rheumatological disease. By doing so, patients that were more likely candidates for surgery would not skew data. Of the patients included, the average age was 39.9 to 59.7 years where the tendinopathy needed to be confirmed by ultrasound or MRI. Differences were much more prominent in this meta-analysis compared to the small study performed by Kim *et al*. using similar assessment tools such as ASES, VAS, ROM, etc. In the short-term and medium-term follow-ups at 3-6 and 12 weeks, pain reduction differences were quite minimal, only showing substantial changes at the 24-week follow-up after heterogeneity was eliminated.[15] Although the control group had three subgroups consisting of the sham injections, dry needling, and physiotherapy, no significant differences were noted comparing each one to the PRP. Regarding functional improvements, PRP showed slightly better results in short, medium, and long-term evaluations but nothing significant to choose one treatment's realm over another.[15]

In another systematic review and meta-analysis published in PLoS ONE performed by Hamid *et al*, 8 studies were reviewed to determine the effectiveness of platelet-rich plasma in long-term pain control and shoulder function in patients with rotator cuff tendinopathies.[16] In total, there were 976 participants. The control varied; 4 incorporated normal saline injections and the other 4 utilized rehabilitation programs and dry needling. Very similarly to the last two

studies, these patients also required MRI or ultrasound diagnosis in order to be eligible for participation. The importance of the inclusion of this study is that it includes a lot of data with varying follow-ups ranging from 2-months to 2-years. The patient sample size consisted of those 18-70 years-old where they were assessed using similar tools, again, such as ASES, WORC, SPADI, VAS, DASH, ROM, etc. to determine shoulder pain, ROM, and functionality in comparison to their baseline prior to treatment. Due to the extreme wide variety of assessment tools, it adds quite a bit of variation in the results.

According to this meta-analysis, there were no significant differences in VAS pain scores between the PRP group and control groups in the short term when assessed at 3 weeks.[16] However at the medium and long-term follow-up assessments taking place at 6 and 12 months, the PRP group showed significantly less pain symptoms compared to the control.[16] When assessing the SPADI scores for functionality, though, there is no specific correlation to the pain scores. The PRP group showed better results at 3 weeks, 3 months, and 6 months compared to the control.[16] This study is able to support the idea that PRP is safe and effective for intermediate and even long-term shoulder pain and functionality for those with rotator cuff tendinopathies compared to traditional nonsurgical interventions but there were many limitations. There were too many variations in studies being compared and even too many assessment tools being used to not allow for much consistency. Regarding trends, though, it does follow what was previous thought and has many foundations that help support PRP.

Platelet-rich Plasma and Surgery:

As discussed, both platelet-rich plasma and surgical interventions have their effective characteristics for the management of rotator cuff tendinopathies. Platelet-rich plasma promotes healing and growth factors to the area of injury allowing for tissue to regenerate. Surgery

provides the true intervention to physically manage the injury and correct the abnormality. When a tear is present, surgery tends to be the course of action after nonsurgical interventions have not been effective. The thought here is that when combining surgical interventions and then implementing PRP injections post-operation, PRP can promote healing and strengthening of the rotator cuff more rapidly allowing for greater long-term outcomes associated with pain and functionality.

In the American Journal of Sports Medicine, Malavolta *et al* conducted a randomized control study to evaluate the 5-year outcomes of patients who received surgery to repair their torn rotator cuff with and without the addition of platelet-rich plasma.[17] The 51 patients included in the study had small to medium tears to the supraspinatus that were required to be confirmed by MRI and have no history of retraction and were all surgically repaired by the same surgeon. If there were other tears, fatty degeneration, glenohumeral arthrosis, previous surgery, rheumatological diseases, fibromyalgia, or platelet counts less than 150,000/mm^3 patients were excluded from the study. The study was focused on performing a functional assessment of the shoulder using the UCLA shoulder rating scale and Constant shoulder scale, used the Visual Analogue Scale (VAS) for pain, and MRI to assess rate of retear. There were 26 patients in the PRP group with 25 in the control group. All patients participated in the same rehabilitation programs including NSAIDs and immobilization initially for 6 weeks, active-assisted and active-free exercises from weeks 6-12, and muscle strengthening after week 12. Patients were evaluated at 3, 6, 12, 24, and 60-months post-operation. The mainstay of this study was to determine the 5-year outcomes compared to baseline and after statistical analysis.

It was concluded that there was no significant differences between the PRP group and the control group. Using the UCLA scores, the mean preoperative scores were 13.6 with a standard

deviation of 3.8 for the control group and 14.2 with a standard deviation of 4.6 for the PRP group.[17] When reevaluated at the 60-month mark, the mean scores were 32.5 with a standard deviation of 3.8 and 32.1 with a standard deviation of 4.6 respectively.[17] The VAS scores for pain also reported no major differences with the preoperative or postoperative scores. Preoperative evaluations were 6.9 with a standard deviation of 1.9 for the control and 6.6 with a standard deviation of 1.6 for the PRP group. Postoperative evaluations were 82.0 with a standard deviation of 9.5 and 82.1 with a standard deviation of 11.0 respectively.[17] MRI evaluations also reported no significant differences. Even with no significant findings, it was vital for comparative purposes that this study includes surgical interventions, traditional nonsurgical interventions in rehabilitation, and the inclusion of PRP.

The Journal of Orthopaedic Surgery and Research published a study by Mao *et al* conducting a study that also supports the previous findings by Malvolta *et al*. The main difference between the two studies were volume of patients evaluated and time in which patients had follow-up. This meta-analysis used a total of 8 studies including 219 patients where PRP was used against a control to determine if it would improve outcomes within 12-27 months and reduce the rate of retears. Using the ASES, UCLA scale, and Constant score for patient functional outcomes, they did not note any significant differences in the control groups compared to the PRP groups.[18] Of the 8 studies, 7 evaluated the retear rate in which the results were consistent throughout and not presenting an alarming retear rate from one group to the other. Four of the studies used ASES scores showing a weighted mean difference of -1.25, 95% CI of -2.58 to 0.08, and a $P = 0.066$ showing no significant clinical differences either.[18] The two studies that used the UCLA score showed a weighted mean difference of -0.97, 95% CI of -2.56 to 0.62, and a $P = 0.230$ again showing no major differences.[18] And the four studies that used the

constant score were very similar: a weighted mean difference of -0.73, 95% CI of -1.30 to 2.77, and a $P = 0.481$.[18] With it being a larger sample size, it is important to note that this evidence does help support that case the PRP does not include any additional benefits in the process of healing after arthroscopic rotator cuff surgery. One limitation with this being a meta-analysis compared to Malvolta *et al* is that they had all of their participants from the same surgeon and on the same rehabilitation regimen as well keeping data more reliable regardless if this data shows similar trends.

On the contrary to the previous two articles, the Journal of Orthopaedic Surgery and Research published a meta-analysis study of randomized control trials performed by Han *et al* showed differing results. This study similarly focused on indicating whether or not the use of PRP in conjunction with surgery will improve functional outcomes and decrease the likelihood of retear within a timeline of 6-16 months.[19] Though very similar in structure by again using the Constant score, UCLA score, and simple shoulder test score for functionality and possibility of retear, the results differed. This meta-analysis evaluated 13 randomized control trials for patients who received a combination of both single row and double row rotator cuff repairs. Of the 12 that reported retear rate, retears occurred in 63 of 392 patients (or 16%) for the patient group which received the PRP treatment whereas there were 90 of 381 patients (or 24%) for the control groups.[19] The integrity of the repair was determined by MRI, CT, or ultrasound. The Constant score was also used in 9 studies for 615 patients and suggested that rotator cuff improvement post-operation could be accelerated with the PRP. The mean difference was 2.31, 95% CI was 1.02-3.61, and $P = 0.0005$.[19] The UCLA score and ASES were also shown to be significantly higher in the PRP groups compared to the controls in the 7 studies they were incorporated in. It was also important to note that 5 of the studies used VAS for pain where the PRP groups

reported lower pain scores with a mean difference of -0.35 and a 95% CI of -0.57 to -0.13.[19] The theory behind this study is that PRP enhances growth factors to promote healing as previously reported. Interestingly enough, the results differ from other studies conducting meta-analysis as well.

In an article published by Nature Research, Fang *et al* performed a meta-analysis of randomized control trials to determine if applying PRP during arthroscopic rotator cuff repairs of full-thickness rotator cuff tears would impact retear rate and functional outcomes. What was interesting about this meta-analysis is that it actually indicated that a couple of the previous studies displayed contradicting results. Mao *et al*, as previously stated, noted that there were no significant differences in the PRP group vs the control group when it came to surgical outcomes with the implementation of PRP. In the Han *et al* study, they reported the opposite stating that the PRP group displayed better outcomes than the group that did not receive PRP post-operation. By acknowledging the conflicting results, the Yang *et al* meta-analysis selected varying studies with similar structures to the other two. By doing so, they were able to follow the same methodologies with different patient pools to develop their own findings giving a well-rounded comprehensive approach to determine if PRP truly does have an impact on post-operative outcomes for rotator cuff repairs.

In total, 7 studies were used with 273 patients in the PRP group with 268 in the control group. Patient diagnosis of a tear was required to be confirmed by MRI and the longest follow-up for ranged from 12-60 months. After assessing retear rate to determine the structural integrity of the rotator cuff, Constant score and UCLA score for functionality, and VAS for pain, the results were quite interesting. Retear rate was significantly lower in the PRP group with RR=0.38, 95% CI (0.22,0.68), P=0.0009).[20] Regarding Constant score, only the short term

showed a minimally better score for the PRP group, but the long term gave similar statistics. The UCLA showed significantly higher scores in the short term for the PRP group but again no significant differences in the long-term like the Constant.[20] As for the VAS assessing pain, there were slight differences in the short-term favoring the PRP group but no major differences to note for the long-term.[20] Refer to table 4 for the statistical differences.[20] According to these findings, incorporating PRP for post-operative management of these rotator cuff surgery patients shows benefits in their short-term recovery time regarding pain and functionality and also show improvements in retear rate. All are important to note to improve overall outcomes of these procedures to decrease the number of cases in the future.

Methods:

This research was conducted with the use of Google Scholar, PubMed, and ScienceDirect by performing a systematic database search for peer-reviewed articles of significant relevance to the topic at hand. During the search, articles were originally selected within the range of 2018 to present to have the most up-to-date information regarding rotator cuff tendinopathies. As the search continued for clinically relevant data, additional articles were sourced from articles themselves. After the search was conducted, 20 articles were pulled to develop an all-encompassing clinical review comparing traditional surgical and nonsurgical interventions to platelet-rich plasma injections in improving long-term outcomes for patients with rotator cuff tendinopathies. While conducting the search, keywords and phrases such as “rotator cuff anatomy”, “biomechanics rotator cuff tendinopathies”, “rotator cuff surgery”, “rotator cuff non surgical”, “rotator cuff PRP”, “rotator cuff treatments”, “rotator cuff tendinopathies”, and “double row” were highly utilized and yielded the best results. In order to understand the rotator cuff and mechanisms of injury further, *CURRENT Medical Diagnosis & Treatment* was also

utilized. The textbook provided an anatomical foundation as well an understanding for how the rotator cuff is injured.

Discussion:

With rotator cuff tendinopathies continuing to be a growing problem, it is important for medical providers and populations alike to understand the causes, interventions, and proper methods of management to provide the best outcomes to patients. Conflicting findings continue to make it difficult to entirely understand which is the best for long-term outcomes for these patients. The newest intervention attempting to make a breakthrough is the use of platelet-rich plasma injections. PRP in simple terms is essentially a high concentration of plasma to promote an influx of growth factors to enhance the healing process. The idea is for long-term success for these patients to have an improvement in pain, functionality, range of motion, and integrity to prevent future tears of the shoulder. Physicians have been experimenting with PRP preoperatively as an alternative to traditional nonsurgical managements such as corticosteroids, physical therapy, NSAIDs, and nerve blocks/ablations. It has also been used postoperatively to enhance the healing process and improve the integrity of the damaged tissue. Studies seem to have results not consistent with one another which seems to be the outstanding problem.

Preoperative management of rotator cuff tendinopathies has traditionally centered around the use of corticosteroids, NSAIDs, physical therapy, and nerve blocks/ablations in serious cases when surgery is contraindicated. Each method has proven to have their benefits on pain, healing, functionality, and strengthening all which are key points to focus on when treating the patient. Physical therapy has shown success rates regarding strengthening and functionality in upwards of 75-91% of patients. With corticosteroids and NSAIDs, they both do benefit the patient in the short-term regarding the patient's VAS pain assessment as they are meant to decrease

inflammation but compared to a placebo control there were no significant findings for the long-term outcomes. Due to these results, comparative studies have come to the table comparing PRP interventions to interventions such as corticosteroids and physical therapy. Ibrahim *et al* determined that when assessing ROM, functionality, and VAS for pain, corticosteroids and PRP both provided similar results not indicating one as being superior to the other. The one difference that was noted was PRP promoted better healing according to ultrasound leading to a lesser likelihood of retear and further injury. But in other similar studies, it was shown that the VAS and ROM were significantly improved compared to the corticosteroid group. When comparing the PRP group to a physical therapy group, findings also varied from study to study. For example, the Kim *et al* study provided data that was able to show PRP improved functionality of the shoulder at 24 weeks but the Lin *et al* study contradicted those findings and did not provide any significant differences between PRP and physical therapy. There just seemed to be too many contradicting factors in these studies comparing PRP to traditional nonsurgical interventions which does not entirely support one over the other. But one thing to note is that none of the studies encountered provided data showing PRP being a worse nonsurgical intervention for rotator cuff tendinopathies.

For patients that fail nonsurgical interventions and are required to undergo arthroscopic surgery to repair the rotator cuff, the main goal is to get the patient back to their preoperative state or better. Again, this comes down to pain, functionality, range of motion, strength, and likelihood for retear. What physicians have begun doing is providing patients with PRP injections post-operation to, in theory, promote healing so the patients can get back to full health more rapidly. But the importance of the possibility of more rapid healing needs to align with the importance of reducing the chances of retearing the rotator cuff. The studies conducted to

compare primarily used a PRP group and then a control group that did not receive PRP. In most studies, it was reported that these patients also participated in physical therapy programs to improve strengthening and functionality of the shoulder. The most extensive study conducted by Malavolta *et al* followed patients for 5 years and did not show any significant differences between the PRP and non-PRP groups. A subsequent study performed by Mao *et al* provided similar results as they also did not note any notable findings to support one group vs. another. But contradictory to both of those studies, two meta-analyses' conducted by Han *et al* and Fang *et al* provided data to show that the PRP group differed from the control. There was evidence associated with the likelihood of retear showing only 16% for those who received PRP compared to 24% for those who did not. There was also support showing reduced VAS for pain and improved ASES and UCLA scores for functionality. The support indicating the benefits of PRP for postoperative management of rotator cuff tears is encouraging, but at the same time difficult to draw a definitive method for management due to the conflicting studies structured in very similar ways. With more research, fundamental studies, and patient cooperation for those involved in these studies, there will be advances and allow for these patients to have improved outcomes.

The information found in the studies comparing surgical interventions, traditional nonsurgical interventions, and platelet-rich plasma injections creates less clarity than preferred. The monotherapy of each provided benefit as depicted in all studies, but the lack of consistency regarding which is the superior intervention made this difficult to actually assess. Multiple studies stated that PRP would be more beneficial as a monotherapy when compared to traditional nonsurgical interventions. But alternative studies stated that there was no difference between one versus another. Similarly, PRP was viewed to be more beneficial when used in conjunction with

arthroplasty double row rotator cuff tear repair for the long-term outcomes regarding patient's pain, range of motion, and functionality. But, again, there were studies contradicting those findings stating that there was no difference between the PRP group and the control. What is known up to this point is that all of these interventions are helpful in the long-term outcomes of these patients. Without the consistency of the evidence throughout these studies, one can only continue to hypothesize that a combination of all three will reign superior to monotherapy. Incorporating physical therapy, PRP, and surgery if a tear is present seems like a viable option to manage these patients and have the best outcomes. Combining these studies suggests evidence that this would be beneficial but the study needs to actually be conducted while maintaining patient enrollment to get a true assessment.

All of these studies contained their limitations possibly inhibiting the validity of the results. In the individual studies, sample size was a common trend observed. With smaller groups of patients, they were not able to properly acquire sufficient data regarding retear rate and there was also a higher than desired dropout rate. In order to have more valid data, the sample size needed to be substantially larger and maintain through the entire studies. It was also difficult to determine initial tear size and limitations because multiple meta-analyses were used and there was no access to some of the patient's true baseline. When not having access to the initial tear information, it makes it much more difficult to determine if the patient may be susceptible further injury and also retear. One final limitation that is quite common is the fact that pain is very subjective and difficult to measure. Filling out the questionnaires to determine how the patient is progressing is good, but it does not necessarily provide the information on healing as some patients may present with greater pain tolerance than others. In order for these studies to continue working toward providing validity for the treatment methods for rotator cuff

tendinopathies, there is an importance in maintaining a large sample size, gain access to entire patient profiles, monitoring lifestyle and activity after treatment, and continue to develop methods to assess for pain, range of motion and functionality in as minimally subjective ways possible. It is also quite difficult to entirely monitor post-intervention lifestyle choices and medication use allowing for discrepancies in outcomes.

Conclusion:

Rotator cuff tendinopathies will continue to be a problem that medical providers will encounter and the best interventions for patient outcomes need to be understood. The prevalence of these injuries remains high due to the anatomical makeup and excessive daily involvement of the shoulder as well as factors reducing the structural integrity such as age. As shown, an age greater than 50, diabetes, and overhead activities are the major contributors to these injuries and none of these are going away. Regarding the implementation of platelet-rich plasma, the question remains if it is more beneficial compared to traditional surgical and nonsurgical interventions for long-term outcomes regarding pain, range of motion and functionality. It has definitely shown its benefits in implementation prior to surgery and post-surgery. It has even provided evidence that it promotes better healing in the short term, greater reduction of pain, and improved functionality and range of motion than traditional nonsurgical interventions used to manage rotator cuff tendinopathies before and after surgery. The issue that seems to continue surface is the lack of consistent evidence. Prior to surgery, PRP did not always outperform traditional nonsurgical interventions. And postoperatively, studies were able to display evidence that supported no significant differences between receiving PRP and placebo. More research needs to be done to entirely support the idea that platelet-rich plasma is the superior to options such as corticosteroids, physical therapy, and NSAIDs prior to surgery and the specific need for it to

enhance long-term outcomes by implementing it post-surgery. Pain, range of motion, and functionality are all key contributors to a patient's long-term success, which all need to continue to be monitored and adjusted for all patients suffering from rotator cuff tendinopathies.

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Appendix:

Table 1:

Subgroup Analysis: Tear Size and Clinical and Radiological Results[a]

	Mean ± SD, Median [Q1-Q3], or Frequency Ratio			
Group	Overall	C1-C2	C3-C4	*P* Value
SSp, integrity:nonintegrity	0.53:0.47	0.68:0.32	0.29:0.71	**.0002**
SANE score, 0-100	80 [70-100]	90 [70-100]	80 [60-90]	.0856
NRS score, 0-10	0.00 [0.00-3.25]	0.50 [0.00-2.00]	0.00 [0.00-6.00]	.4803
ASES score, 0-100	90.00 [73.33-100.00]	92.50 [78.33-100.00]	86.67 [51.67-98.33]	.1048
SST score, 0-12	11.00 [9.00-12.00]	12.00 [10.00-12.00]	10.00 [9.00-12.00]	.1015
Satisfaction, 1-4	1 [1-1]	1 [1-1]	1 [1-1]	.4674
CMS total, 0-100	78.05 [65.63-85.20]	81.50 [70.47-86.54]	69.96 [60.17-79.39]	**.0007**
Pain, 0-15	14.75 [10.00-15.00]	15.00 [11.00-15.00]	14.00 [8.75-15.00]	.1458
Daily activities, 0-20	20.00 [16.00-20.00]	20.00 [18.00-20.00]	18.00 [13.00-20.00]	**.0073**
Movement 0-40	38.00 [32.00-40.00]	38.00 [34.00-40.00]	35.00 [26.00-38.00]	**.0084**
Strength, 0-25	7.92 [4.35-13.39]	10.56 ± 5.93	5.94 [2.05-9.76]	**.0007**
Strength, kg				
Abduction	3.60 [1.98-6.09]	4.475 [3.11-7.05]	2.70 [1.06-4.44]	**.0006**
Flexion	4.43 [2.34-6.80]	5.59 ± 2.76	2.55 [1.60-5.29]	**<.0001**
Range of motion, deg				
Abduction	180.0 [143.8-180.0]	180.0 [170.0-180.0]	170.0 [110.0-180.0]	**.0174**
Flexion	180.0 [170.0-180.0]	180.0 [176.3-180.0]	180.0 [140.0-180.0]	**.0164**
AHD, mm	8.63 [5.41-10.50]	9.23 ± 2.63	5.91 ± 3.35	**<.0001**
OA grade				
Hamada, 1:>1	0.72:0.28	0.86:0.14	0.47:0.53	**<.0001**
Samilson-Prieto, 0:>0	0.51:0.49	0.64:0.36	0.29:0.71	**.0009**

[a]Bold indicates $P < .05$. AHD, acromiohumeral distance; ASES, American Shoulder and Elbow Surgeons; C1-C2, small tear size; C3-C4, large tear size; CMS, Constant-Murley Score; NRS, Numeric Rating Scale; OA, osteoarthritis; Q1, first quartile; Q3, third quartile; SANE, Simple Assessment Numeric Evaluation; SSp, supraspinatus tendon; SST, Simple Shoulder Test.

Table 2:

Baseline and clinical characteristics of the PRP and corticosteroid groups

Variables	**Groups**			
	PRP (*n*=30)	**Corticosteroid (*n* = 28)**	**Overall**	***p* value**
Age—years	57.33 ± 9.80	53.60 ± 7.24	55.53 ± 8.79	0.108
Sex—no. (%)				0.644
Male	5 (16.7)	6 (21.4)	11 (19)	
Female	25 (83.3)	22 (78.6)	47 (81)	
VAS score	6.66 ± 2.26	5.53 ± 1.80	6.14 ± 2.15	0.041
Flexion—degrees	116.90 ± 37.58	135.42 ± 35.70	126 ± 38.15	0.060
Extension—degrees	35.16 ± 10.78	41.42 ± 10.87	38.21 ± 10.19	0.017
Abduction—degrees	102.83 ± 36.07	118.46 ± 41.43	109.32 ± 39.50	0.130
Adduction—degrees	20.50 ± 8.23	23.21 ± 7.09	22.05 ± 7.73	0.186
Internal rotation—degrees	64.26 ± 17.06	60.17 ± 19.41	62.73 ± 18.26	0.397
External rotation—degrees	59.66 ± 23.81	57.14 ± 24.69	58.39 ± 24.49	0.694
WORC score	32.85 ± 19.43	35.56 ± 17.97	34.46 ± 18.81	0.585
DASH score	54.02 ± 18.24	52.50 ± 20.32	53.51 ± 1925	0.764
Supraspinatus thickness—mm	6.97 ± 1.46	7.47 ± 1.38	7.20 ± 1.43	0.354

PRP platelet-rich plasma, *VAS* Visual Analogue Scale, *WORC* Western Ontario Rotator Cuff, *DASH* Disability of Arm-Hand-Shoulder

Table 3:

Comparison of PRP and corticosteroid groups during a 3-month follow-up.

Variables	Groups								*p* value	Fisher value	Effect size
	PRP				Corticosteroid						
	Baseline	1st week	1st Month	3rd Month	Baseline	1st week	1st Month	3rd Month			
VAS**	6.66 ± 2.26	5.36 ± 1.89	3.75 ± 2.15	3.08 ± 2.14	5.53 ± 1.80	4.86 ± 1.99	3.84 ± 2.07	3.88 ± 1.99	0.023	3.868	0.670
Flexion—degrees**	116.90 ± 37.58	118.40 ± 40.03	132.73 ± 39.06	139.50 ± 34.6	135.42 ± 35.70	139.42 ± 36.80	140.09 ± 36.98	148.65 ± 34.5	0.112	2.326	0.041
Extension—degrees**	35.16 ± 10.78	37.50 ± 10.40	46.16 ± 11.19	50.33 ± 9.18	41.42 ± 10.87	42.69 ± 13.05	50.76 ± 9.02	52.50 ± 8.15	0.302	1.220	0.022
Abduction—degrees**	102.83 ± 36.07	107.43 ± 37.19	115.66 ± 36.75	141.83 ± 36.04	118.46 ± 41.43	119.61 ± 41.10	127.50 ± 43.68	138.26 ± 40.24	0.081	2.572	0.045
Adduction—degrees**	20.50 ± 8.23	21.16 ± 8.37	26.50 ± 4.57	28 ± 3.61	23.21 ± 7.09	26.53 ± 6.28	27.69 ± 4.73	28.46 ± 4.18	0.011	5.087	0.086
Internal rotation—degrees**	64.26 ± 17.06	68.50 ± 17.12	78.50 ± 13.3	82.16 ± 10.39	60.17 ± 19.41	63.84 ± 22.64	77.50 ± 15.18	79.61 ± 13.55	0.741	0.333	0.006
External rotation—degrees**	59.66 ± 23.81	65.83 ± 23.12	74.83 ± 20.36	76.66 ± 18.30	57.14 ± 24.69	60.19 ± 26.81	64.03 ± 26.42	65.57 ± 26.39	0.036	3.475	0.060
WORC score**	32.85 ± 19.43		40.66 ±18.76	49.93 ± 22.36	35.56 ± 17.97		44.87 ± 21.59	48.46 ± 20.60	0.315	1.166	0.021
DASH score**	54.02 ± 18.24		48.83 ± 13.53	40.83 ± 18.19	52.50 ± 20.32		44.77 ± 17.89	41.05 ± 15.69	0.520	0.658	0.012
Supra-spinatus thickness—mm*	6.97 ± 1.46			6.36 ± 1.06	7.47 ± 1.38			7.40 ± 1.07	0.119	2.509	0.044

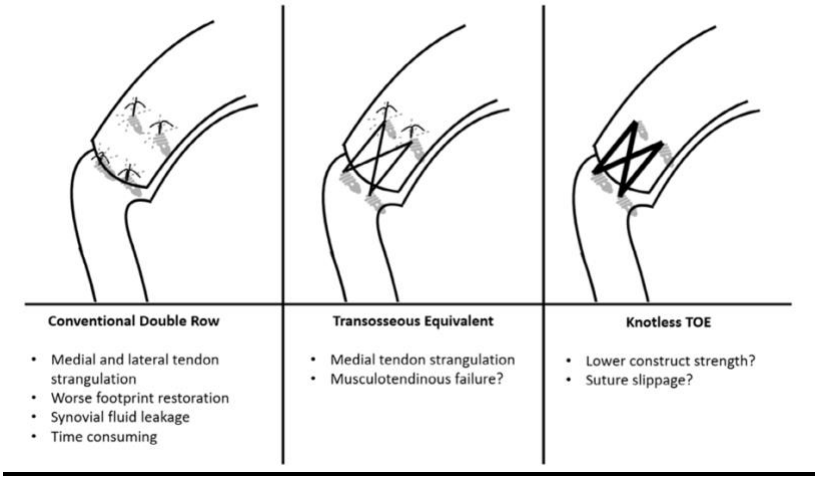
PRP platelet-rich plasma, *VAS* Visual Analogue Scale, *WORC* Western Ontario Rotator Cuff, *DASH* Disability of Arm-Hand-Shoulder, *Effect size* Eta squared
*$p = 0.051$, **$p < 0.001$, these two represent difference and changes during follow-up in the PRP and corticosteroid groups separately

Table 4:

Outcome	Single-row repair	Double-row repair	Overall
Retear rate (RR, 95% CI)	0.36 [0.08, 1.56]	0.40 [0.21, 0.77]*	0.38 [0.22, 0.68]*
Short-term Constant score (MD, 95% CI)	4.10 [1.59, 6.61]*	2.37 [−0.28, 5.03]	3.28 [1.46, 5.11]*
Long-term Constant score (MD, 95% CI)	−0.10 [−4.35, 4.15]	–	−0.10 [−4.35, 4.15]
Short-term UCLA score (MD, 95% CI)	1.76 [0.82, 2.69]*	1.10 [−0.59, 2.79]	1.60 [0.79, 2.42]*
Long-term UCLA score (MD, 95% CI)	−0.32 [−1.89, 1.24]	–	−0.32 [−1.89, 1.24]
Short-term DASH score (MD, 95% CI)	−0.05 [−4.35, 4.25]	–	−0.05 [−4.35, 4.25]
Short-term VAS score (MD, 95% CI)	−0.28 [−0.49, −0.08]*	−0.11 [−0.19, −0.03]*	−0.14 [−0.23, −0.05]*
Long-term VAS score (MD, 95% CI)	−0.16 [−0.33, 0.01]	–	−0.16 [−0.33, 0.01]

Summary of subgroup analysis. '*' Shows statistical differences; '–' means not assessable. *UCLA score* University of California at Los Angeles activity score, *DASH score* disabilities of the arm, shoulder, and hand score, *VAS* visual analogue scale score, *RR* risk ratio, *MD* mean difference, *CI* confidence interval.

Image 1:



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